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# NOTATION AS INSTRUMENT: FROM REPRESENTATION TO ENACTION

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## ABSTRACT

The paper explores the hybridization of notation and instrument as a cognitive movement from representation to enaction. Features of such hybridization are latent in every notation, as a mix of descriptive and prescriptive functions. Current advances in the fields of computer music representation (interactive scores) and New Interfaces for Musical Expression, with precedents in graphic and action-oriented scores, are turning notation into a shared multimodal platform between composer and performer, liquidizing the limit between notation and instrument. We will present this dynamic rapport between scores and interfaces (haptic interactions, INScore, GesTCom, post-Klaus K. Hübler tablature notations of decoupled action-structures) in the light of theoretical models (enaction defined as navigation of affordances from the field of embodied and extended cognition, Leman's action-reaction cycle extended from instrument-making into notation, Veitl's conception of software as tablature, Atau Tanaka's definition of instruments as open-ended systems etc.). We are following an explicit line from new interfaces involving notation back to graphic and action-oriented scores, considering them in the theoretical framework of enaction.

## INTRODUCTION: ONTOLOGY OF NOTATION TODAY

In an extension of its primordial role as recording of musical praxis and mnemotechnics, music notation today is still assuming the central position in the sophisticated communicative chain of conception, composition, performance and reception.

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This role persists despite the 'performative turn' in musicology, which advocates the multiple nature of the musical work of art beyond an *Urtext* and into performances, recordings and improvisations [1, 2]; and despite the problematizations in view of music's medial extension, paradigmatically in early electronic music. [3]

The role of notation today could be described as one of attracting compositional activity and releasing performing activity. All compositional activity is aiming at the generation of notation, all performing activity is itself generated by notation, thus a linear model of musical communication.

Interestingly enough, the linear nature of this arrangement is perplexed by the omnipresence of performance inside composition and vice versa: From a composer's perspective, notation attempts to codify a future presence of performing bodies and instruments in virtue of their real absence in the act of composition; and from a performer's perspective, this set of virtual presences in the form of notation has to be deconstructed (through the understanding of the notation and of the composer's intention) and reconstructed in material presences.

Alternatively to this ambivalent communicative chain, notation can be viewed as equal constitutive part in a self-organized, feedback-loop dynamic system, in a formulation originating in the field of embodied/extended/enacted cognition [4]. At its current state of development notation can be thought of and further developed into *a shared multimodal platform for both composers and performers* in the form of a tablature and/or interface, that is: in the form of an instrument.

We will explore different manifestations of such hybridization, starting with Tomás and Kaltenbrunner *Tangible Scores* [4].

## TANGIBLE SCORES AND GESTCOM AS COMPOSER AND PERFORMER PERSPECTIVES RESPECTIVELY

### Tomás-Kaltenbrunner Tangible score: *inherent score* and multi-morphophoric sound elements

The question of an inherent-in-the-instrument score frames in new terms the problem of interaction design and affordance exploration of instruments and notations alike<sup>1</sup>.

The problem of a differentiation between scores and interfaces is largely debated in the NIME community. A NIME designer develops a notation system that is inherent to the instrument. The designer thus cancels the difference between music composer and instrument maker: *the score is the instrument*. The definition is compatible with Atau Tanaka's definition of instruments as *open-ended systems*, whose architecture includes a structural-compositional layer, next to the input and output systems, mapping algorithms and sound synthesis systems.[5]

The example provided by *Tangible Score* highlights very well this particular evolution. He claims that different layers, namely the instrument and the score, accompany the interaction between the composer and the performer. However, the evolution of electronic instruments implies a radical change in this perspective: the construction of the instrument is not only an instrument-maker realization, but it becomes an act of composing.

*Inherent scores* are in this sense an expansion of what an instrument normally is: these instruments expand and reinforce their affordances, turning into objects acting in the sense of musical composition. The instrument implies gestures and sounds, exploding in a multiplicity of instrumental morphophoric elements. Duchez defines morphophoric: "The notion herein referred to as morphophoric - or form-bearing - element, has always and unfailingly guided musical action, that is to say strategies of production (inspiration, invention, representation, execution) and reception (listening, memorization). But this essential guidance is first of all only a more or less conscious, empirical practice based on immediate perception. Its efficiency, therefore, though direct and reliable, is limited, and it corresponds to what are generally called "primitive", orally-transmitted musics" [6].

### Graphic scores as proto-inherent scores

Tomás and Kaltenbrunner traces back the development of the notion of inherent scores in the 1960s and in particular in graphic scores.

The NIME designer programs the affordances. In this sense the instrument tends to be part of the composition, exactly as a graphic score was in the 50s or 60s. These scores are interfaces of interaction with the instruments: The sound result is open, but conducted by the graphic constructions prescribed by the score. *Inherent scores* are similar to *graphic scores*, despite the fact that the first are sound producing and performable while the latter are only representational. As remembered by Tomás and Kaltenbrunner :

[...] performing became the creative exploration in freedom of the musical affordances, musical reactions or acoustic relations to the physical space performed, without the need of any kind of musical notation.

In this sense, inherent scores are evolutions of graphic scores, conceived as musical interfaces. Composers design the instrument, after Lachenman's motto: "*Konponieren heißt: ein Instrument bauen*".

The *tangible score* is the result of a compositional process that enacts gestures and strategies:

We define a tangible score as the physical layer that is incorporated into the configuration of a digital instrument with the intention of conducting the tactile gestures and movements.

Thus, the tangible score influences and orients the process of enactment of the instrument: it affords tactile gestures and movements. In this sense this instrument embodies gestural scores.

However Tomás and Kaltenbrunner focuses mainly on the physical interaction, avoiding the problem of the acoustic one. For him *tangible score*,

as a traditional score, it encodes a musical intention and delegates the decoding part to other agents.

That is partially true: a traditional score implies sounds that a gestural one does not. The score of a violin sonata is an encoding of the intention via the gestures, that leaves the decoding to another agent. However we must remark that we can't program differently the sound of a violin. In this sense the *tangible score* is not exactly traditional, but rather an exciting new extension of traditional possibilities. Each instrument has compositional constraints, but, until now, instruments are the result of historical and intersubjective evolution based on fundamental morphophoric elements – like pitches –; the *tangible score*, as most of NIMEs, is design on open morphophoric elements, that can be chosen by the composer or the performer, inventing in that manner different possible arrangements of *the score*.

<sup>1</sup> A demo of Tangible Score is available at :  
<http://vimeo.com/80558397>.

## GesTCom (Gesture Cutting through Textual Complexity)

A different example of a shared multimodal platform which amalgamates instrument, gesture and notation is the GesTCom. Its novelty lies in that it highlights the enactive potential of traditional musical scores from a performer-specific (rather than composer-specific) perspective.

It was developed in the course of a musical research residency 2013-2014 at the Ircam, as a prototype system based on the *a.* performative paradigm of embodied navigation of a complex score *b.* on the INScore platform and *c.* on the Gesture Follower [7]. The concept of corporeal (or embodied) navigation attempts to offer an embodied and medial performer-specific alternative to the classical UTI<sup>2</sup> paradigm. Instead of a strictly linear arrangement of its formants - understanding notation, then employing purposefully technique and then allowing, in the end, for expressive interpretation-, it proposes the conceptualization of learning and performance as embodied navigation in a non-linear notational space of affordances: The performer “moves” inside the score in several dimensions and manipulates in real-time the elements of notation as if they were physical objects, with the very same gestures that s/he actually performs. This manipulation forms indispensable part of the cognitive processes involved in learning and performing and transforms the notation. This transformation can be represented as a multilayered tablature, as in Figure 1.

*b.* INScore [8] is an open source platform for the design of interactive, augmented, live music scores.

INScore extends the traditional music score to arbitrary heterogeneous graphic objects: symbolic music scores but also images, texts, signals and videos. A simple formalism is used to describe relations between the graphic and time space and to represent the time relations of any score components in the graphic space on a *master/slave* basis.

It includes a performance representation system based on signals (audio or gestural signals).

It provides interaction features provided at score component level by the way of *watchable* events. These events are typical UI events (like mouse clicks, mouse move, mouse enter, etc.) extended in the time domain.

These interaction features open the door to original uses and designs, transforming a score as a user interface or allowing a score self-modification based on temporal events.

INScore is a message driven system that is based on the Open Sound Control [OSC] protocol. This message-oriented design is turned to remote control and to real-

time interaction using any OSC capable application or device (typically Max/MSP, Pure Data, but also programming languages like Python, CSound, Super Collider, etc.)

A textual version of the OSC messages that describe a score constitutes the INScore storage format. This textual version has been extended as a scripting language with the inclusion of variables, extended OSC addresses to control external applications, and support for embedded JavaScript sections.

All these features make INScore particularly suitable to design music scores that need to go beyond traditional music notation and to be dynamically computed.

*c.* The Gesture Follower was developed by the ISMM Team at Ircam [9, 10]. Through the refinement of several prototypes in different contexts (music pedagogy, music and dance performances), a general approach for gesture analysis and gesture-to-sound mapping was developed.

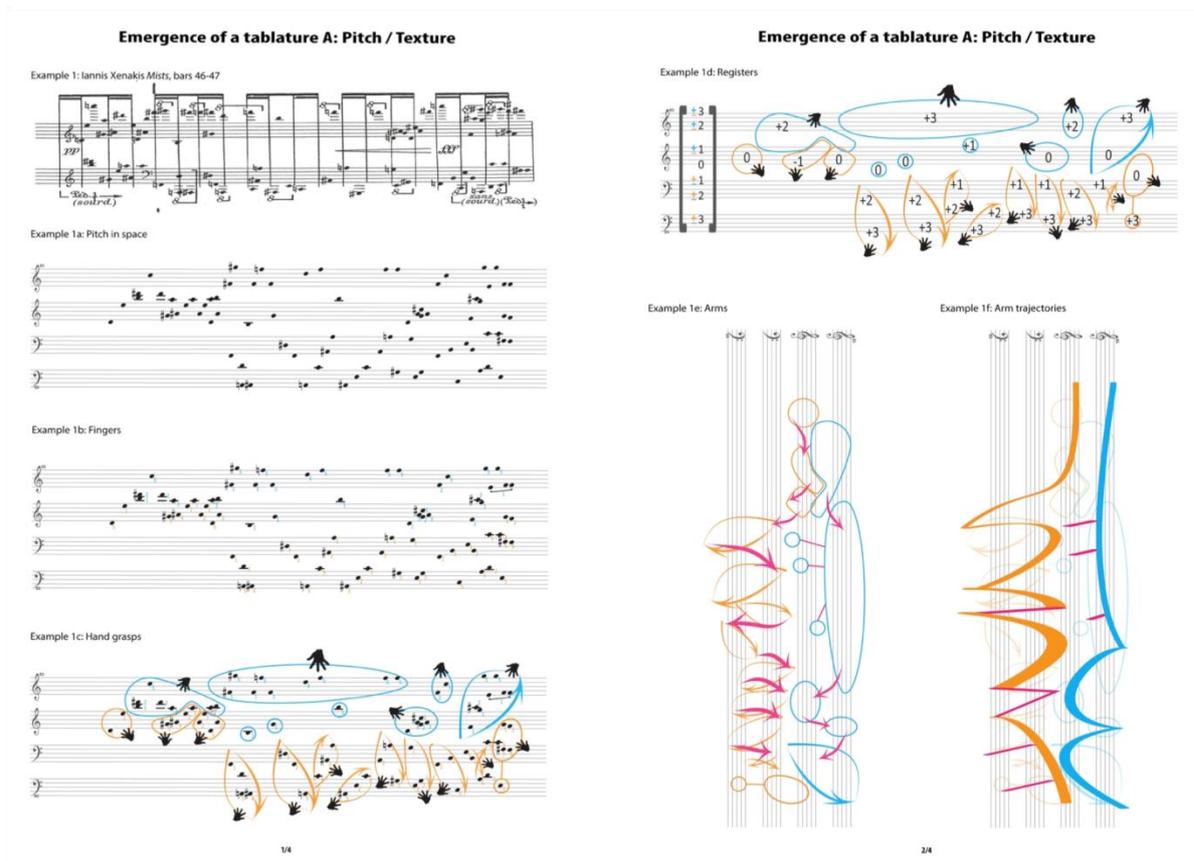
The “gesture parameters” are assumed to be multi-dimensional and multimodal temporal profiles obtained from movement or sound capture systems. The analysis is based on machine learning techniques, comparing the incoming dataflow with stored templates. The creation of the templates occurs in a so-called learning phase, while the comparison of a varied gesture with the original template is characterized as *following*.

The *GesTCom*, equally rooted on embodied navigation, INScore and Gesture Follower, takes the form of a sensor-based environment for the production and interactive control of personalized multimodal tablatures out of an original score. As in the case of Embodied navigation (Figure 1), the tablature consists of embodied representations of the original (Figure 2). The novel part is, that those representations derive from recordings of an actual performance and can be interactively controlled by the player. The interaction schema takes the following feedback loop form (Figure 3).

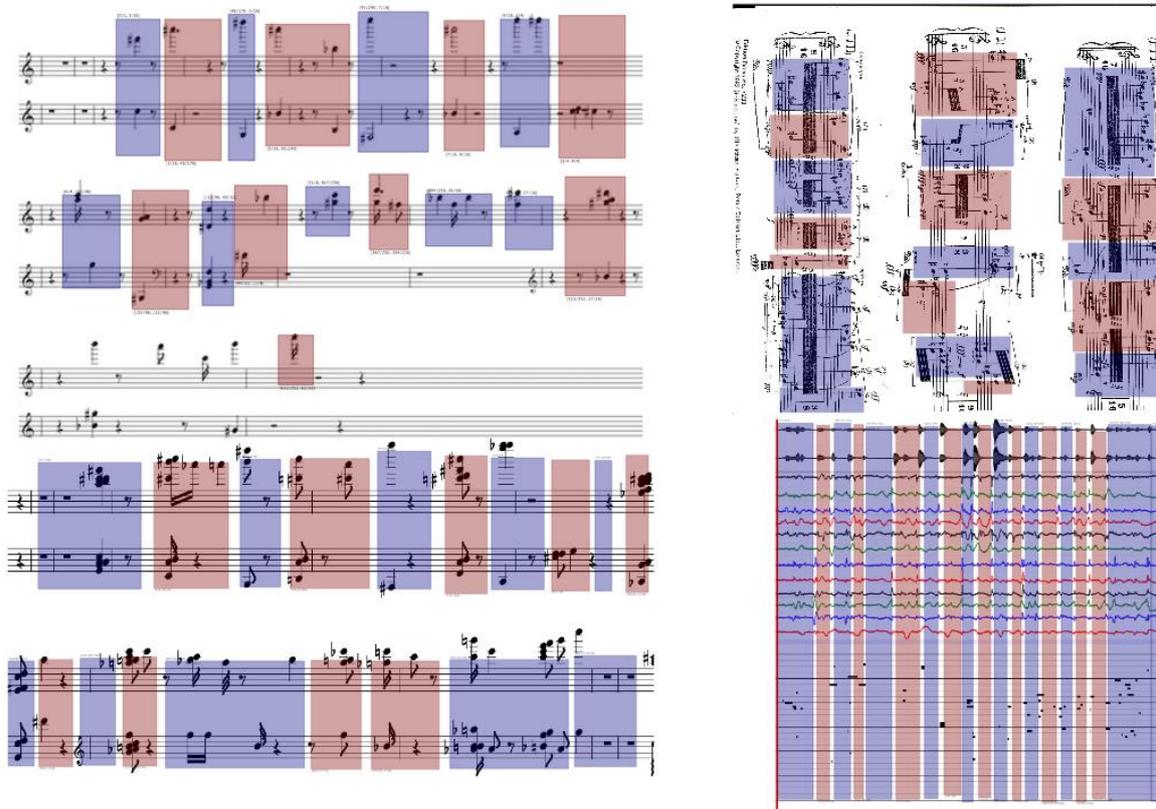
More specifically, the input performative gesture produces four types of recorded datasets (gestural signals, audio, MIDI and video), which are subsequently used for the annotation, rewriting and multimodal augmentation of the original score. Those output notations are embodied and extended: They are produced through performative actions, they represent multimodal data, they can be interactively controlled through gesture and they can dynamically generate new varied performances.

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<sup>2</sup> Acronym for Understanding-Technique-Interpretation



**Figure 1.** The embodiment of a Xenakian cloud / fingers-, hand-, and arm-layer in 1b, 1c, 1f respectively



**Figure 2.** INScore tablature of combined representations. They can be synchronized with video and audio and interactively controlled. The player navigates between the several representations

They can be considered as the visualization and medial extension of the player's navigation in the score-space, creating an interactive feedback loop between learning and performance.<sup>3</sup>



Figure 3. Interaction schema.

## ACTION-BASED SCORES

### Historical account

The relationship between notation and instrument, conceived as trigger of imagined and concrete gestures, emerges in various work since the 60s. The sonic invention of contemporary music restored the problem of notation, multiplying the number of possible morphophoric elements that inform the composition.

Our aim is to indicate some different perspective in an historical order. Even if incomplete, we remember three examples that seem to us to highlight the problem.

### Lachenmann: *Pression*, for solo cello (1969)

One important composer that conceives composing as instrument making is Helmut Lachenmann. In a certain perspective the work of the German composer is inspired by phenomenology and primitivism, and more directly by the references to Schaeffer's *musique concrète*.

Lachenmann defined his music as *musique concrète instrumentale*. However, behind this intriguing definition, the composer is not making instruments, by exploring new possibilities that, still, are strongly idiomatic.

In *Pression*, a renowned piece for solo cello by Helmut Lachenmann, the composer invents new sounds and new writing for the cello. In this piece composed in 1969, the composer prescribes the cellist to play in unorthodox manners, precisely notating the gestures and the places that must be activated by the performer's gesture. The composer explores the instrument, exactly as the *tangible score* must be explored by the performer.

A milestone in subsequent developments towards the representation of independently organized, or decoupled, actions towards indeterminate sound results is offered by the work of Klaus K. Hübler, and in particular his article "Expanding String Technique" [11]. There, Hübler sought to present a "completely new perspective on the instrument" through "an expansion of sound and technique that has its roots in the specific resources of the instrument and its manner of performance".

### Aaron Cassidy: *Second String Quartet* (2010)

The activity of Aaron Cassidy is known for his original approach to the notation problem. Cassidy's scores invest deeply in the notion of musical gesture. Following the examples of Hübler, Barrett and Frneyhough, Cassidy works on the instrumental decoupling: "a separation of the various activities of instrumental sound production" (Figure 4).

The work of Cassidy expands the approach that we highlighted in Lachenmann: Not only is there an exploration of instrumental affordances, but even an exploration of the performer's body affordances.

Therefore the instrument and the score are, means of representation and at the same time stimulation of the gestural content of the player's activity: Physicality is conceived in material terms.

In his *Second String Quartet* (Figure 4) Cassidy resumes the gestural parameters to a unique staff, making an evolution in relation with the former string quartet. The score has the role of being the interface for instrumental and physical enactment of the global musical body – the performer and the instrument. In this sense the score acts as a state space of gestural affordances. The relationship with sound, being open, reveals a coessential element with the *tangible score*: The graphics afford gestures on a known instrument, the string quartet, and the performer interacts with the sounds creating the acoustic output, that is not written in the score. In a similar manner the *tangible score* affords gestures creating open sounds possibilities. On the contrary Lachenmann indicates precisely the sound result.

On both our examples, the score is in the centre of the relationship between gesture and sound, being an abstract symbolic interface for physical movement, even if with different degrees of prescription.

<sup>3</sup> A demo of GesTCom is available at:  
<https://www.youtube.com/watch?v=KV9nQUhhyuI>

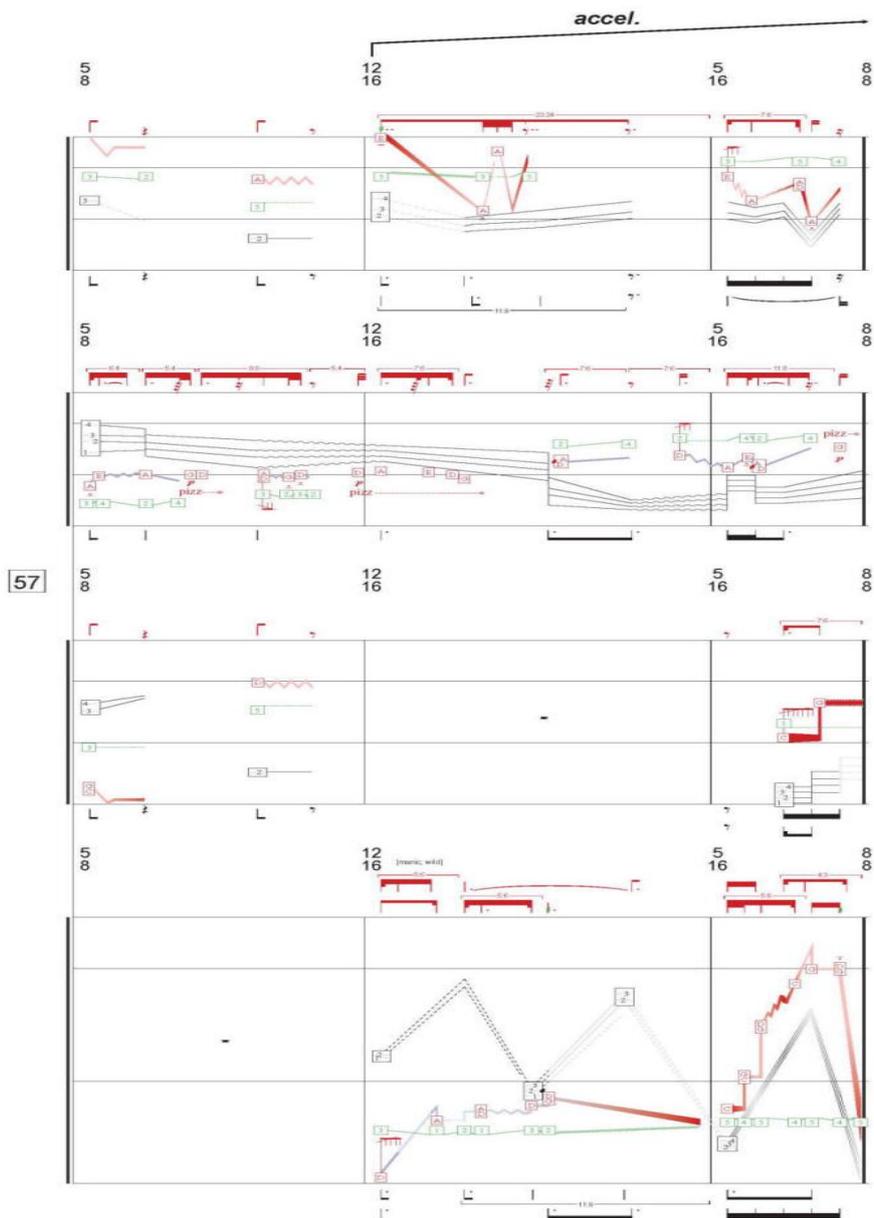


Figure 4. Aaron Cassidy's *Second String Quartet* page

## THEORETICAL FRAMEWORK

### Efforts of projection in time

We try to argue that scores, instruments and compositions seem to have a common essence. If scores are, or might be, abstract symbolic interfaces, and instrument concrete ones, we highlight how the recent evolution of new musical interfaces seems to make the limit fluid.

Scores and instruments not only collimate today in multimodal interfaces, but have, in our opinion, a common essence characterized by the typology of intentionality, based on the effort of projection of the maker: composition of scores or construction of

instruments are forms of projection in time, based on enactive experience.

### *Making Musical instruments, making scores*

Making of musical instruments involves action and perception; it also involves the understanding of the action-relevant value of sounds, the judgment of these sounds in view of musical ideals, and shaping physical environment that produces sound: projections of movements in virtue of the absence of physical presence.

The composer, the performer and the instrument-maker project the sound-object in time: they must project their subjective experience in an intersubjective dimension. Projection is expectation of reality based on past experience.

The action-reaction cycle proposed by Marc Leman as a paradigm for instrument making (and more widely, for music making and perception), frames theoretically, for us, this concept [12]. If the process of instrument making described by Leman as the synergic relationship between “Play, Listen, Judge and Change” is true, then the process of composition can be equally described. In fact

While musical instrument is being built, a set of action-reaction cycles, which may occur on different time scales and perhaps in hierarchical order, transforms matter and energy into a cultural artefact for making music [Leman, 2007: 52]

There are forms of projections through writing that evolve in technology. Performers and composers are entailed in a similar form of projection, characterized by a different degree of distance from the gestural and sonic output. The projection is the conception of a process of accumulation of experience that comes to define the good shape of the instrument and of the score. Leman underlines the process as the Ratchet Effect:

[...] the actual process of instrument-making (ontogenesis) and the history of how an instrument evolves (phylogenesis) can be seen as the result of a repeated cycling of Play, Listen, Judge, Change. The action-reaction cycling is a dynamic model with the capacity to subsume a cumulative process similar to a ratchet effect [Leman, 2007: 54]

In our opinion, we can extend this model from instrument to notation, assuming that in both of them perception induces intentionality and anticipation: “the world is conceived from the viewpoint of action and prediction rather than merely based on the construction of gestalts”.

Scores are the result of a ratchet effect, in the sense that they simulate the economic growing of knowledge during the last centuries, similarly to the instruments. The abstraction of the musical practice in a few number of variables allows a global control of the instruments, that arrives to a certain control of the body of the performer. This kind of prescriptive approach is similar to the machines, that are totally, or almost, controlled. In this sense the composer uses the score as an instrument, as a temporal and physical interface of abstract interaction in time and space: *scores are extensions of the body of the composer in the body of the performer via the projection of the instrument represented by the score*. That creates a singular temporal dimension based on the absence and presence of the instrument: the composer constructs absences and the performer reconstructs the projected presences.

## Notational system as performed system

We would like to suggest a framework of the definition of score as instrument, drawing a line between the programming of the sound result and the design of instrument and scores. We would like to argue that if scores are instruments, then this common essence is still developed in NIMEs.

As highlighted by Tomás and Kaltenbrunner, circuits are conceived as scores and instruments, because their combination implies specific sounds. This relationship is at the basis of the conception of synthetic instruments. Also for Max Mathews, computer is an instrument [13]; at the same time the computer is not a normal instrument, but it performs data that are memorized and activated.

In the case of NIMEs, the computer is still central. The computer controls the loudspeaker, but the musical interface controls the computer. It is a particular instrument that not only can be controlled by interfaces, like keyboards controls organs, but it can be programmed in infinite manners.

The interfaces have a role similar to that of scores: they generate information in real-time, but still record and encode data: interfaces are causal for scores.

Anne Veitl [14], following Cadoz's work [15], focuses on the notion of *causality*, that is the central element of the relation between scores and instrument. The comprehension and the definition of *causality* lies at the centre of the definition of the musical instrument. Veitl's model allows a kind of generalized instrumentality: highlighting the principle of *causality* fundamental, it becomes evident that instruments and score are part of the same causal process.

### Criteria of a performed notational system

Considering the sound synthesis environments partitioned as score and instruments, Anne Veitl proposed to interpret softwares as notational systems.

Veitl proposed six criteria that seem to us to highlight some general properties of notational systems and instruments at the same time. These criteria stress the fact that softwares are notations, and, essentially, performable notations. A notational system is primarily :

- a. *material*: it must be somewhere, memorized on a concrete and existing object, the paper or a hard disc ;
- b. *visible*: that's why the machine language is not a notation, but softwares are visible ;
- c. *readable*: it has to be read by a machine, a human being or both;
- d. *performative*: it describes the action potential of a system. Softwares and computers are highly *performative* because

the material inscription is translated instantaneously in sound;

- e. *systemic*: the signs, or the physical elements of the system can operate structurally ;
- f. *causal*: notation must indicate and enable sounds. It must indicate the manner and the means necessary to produce the sound or the event.

In this sense, for Veitl, softwares are scores, thus NIMEs are expression of this essential character.

## CONCLUSIONS

Technological advances have broadened our conception of notation and instrument as mutually shaping, action-oriented, open-ended systems, as much as they have contributed in their actual, material amalgamation.

Tomás' tangible score and Antoniadis' GesTCom offer instances of new interfaces-and-scores, which have historically followed up from graphic and action-oriented notations. In those instances, notation and instrument share common criteria (Veitl) and evolutionary cycles (Leman) beyond the prescriptive-descriptive classical dichotomy, materializing both representational and enactive cognitive features.

Eventually the very communicative chain and roles between instrument-makers, composers, performers and computer-music designers are to be genuinely rethought as cycles of synergy rather than linear models, with obvious implications for both pedagogy and creation in all respective fields.

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